ROUGHAGE SOURCES FOR BEEF HEIFERS FED ROLLED MILO DIETS

A.L. Goetsch[1], M.A. Funk[2], F.N. Owens[3] and K.B. Poling[4]

Story in Brief

Several roughage types [12 percent alfalfa, (ALF); 12 percent cottonseed hulls, (HULLS); 12 percent whole shelled corn, (WSC) or no roughage (MILO)] were fed with dry rolled milo grain to four cannulated beef heifers. Ruminal fluid volume tended to be least for ALF and HULLS while fluid dilution rate and particulate passage rate tended to be greatest for ALF and least for the WSC diet. Ruminal organic matter (OM) digestion was higher ($P<.05$) for HULLS than for ALF and WSC diets. However, total tract OM and starch digestion tended to be greater for WSC and MILO diets. Ruminal particulate passage rate was negatively related to extent of ruminal digestion. Results indicate that adding 12 percent alfalfa or cottonseed hulls to a rolled milo diet will decrease ruminal and/or total tract digestion of organic matter and starch. Whole shelled corn added as a roughage also decreased ruminal digestion. However, added whole corn did not interfere with intestinal digestion and thereby might allow for more total tract digestion, as compared to added alfalfa and cottonseed hulls.

Introduction

Sorghum grain (milo) in high concentrate finishing diets is fed primarily in the steam flaked or ground high moisture form. High energy and equipment costs for steam flaking and the variable quality of ground high moisture milo have created interest in alternate feeding methods for milo.

As compared with rolling or grinding, steam flaking of milo will gelatinize starch and increase ruminal digestion (Galyean et al., 1979). Hinman and Johnson (1973) reported lower ruminal and total tract starch digestibilities for rolled than for micronized, steam flaked or ground milo diets with 10 percent roughage.

Roughages have been included in highly processed grain diets to prevent ruminal disorders. The dietary need for roughage to prevent acidosis has been alleviated with the use of ionophores like lasalocid (Nagaraja et al., 1982). Besides diluting energy content, roughage generally increases liquid dilution rate and elevates ruminal washout of undigested material. The depression in ruminal digestion by adding roughage is greater with ad lib feeding and with diets containing coarser, more slowly digested grain.

Particle size and flow rate through the intestine also may limit postruminal starch utilization. Postruminal digestion may be less able to compensate for lowered ruminal digestion with rolled or whole grain diets than with steam flaked or ground high moisture grain rations. The objectives of this study were to investigate the effects of feeding lasalocid-supplemented rolled milo diets with 1) no roughage, 2) 12 percent whole shelled corn, 3) 12 percent chopped alfalfa hay and 4) 12 percent cottonseed hulls on site of digestion and passage rates in beef heifers.

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[1]Research Associate [2]Undergraduate [3]Professor, Animal Science [4]Animal Care Supervisor

Experimental Procedure

Experiment 1

Eight beef heifers (251 lb) were used in a crossover experiment. Animals were fed diets at 2.0 percent of body weight (dry matter basis). Rations were rolled milo based containing no roughage (100C) or 7 percent cottonseed hulls plus 5 percent chopped alfalfa hay (88C). Lasalocid and chromic oxide, (an indigestible marker) were added to both rations. Periods lasted 14 days with fecal samples being obtained on the last two days of each period. Feed and fecal samples were dried, ground, and analyzed for dry matter (DM), ash, starch, nitrogen (N) and acid detergent fiber (ADF).

Experiment 2

Four beef heifers (304 lb), fitted with ruminal, duodenal and ileal cannulas, were used in a 4x4 Latin square design experiment. Diets were fed at 2.0 percent of body weight (DM). All diets were rolled milo based and identical, except that 11.6 percent of the DM was provided as chopped alfalfa (ALF), cottonseed hulls (HULLS), whole shelled corn (WSC) or rolled milo (MILO). The latter two are all concentrate diets. Chromic oxide, an indigestible marker, lasalocid and sodium bicarbonate were included in all diets. Rolled milo labelled with ytterbium served as a particulate marker and CoEDTA was the fluid marker. Periods lasted 14 days with ruminal, duodenal, ileal and rectal samples obtained on days 11 through 14. Feed and digesta samples were analyzed for all or part of the following: DM, ash, starch, N, nucleic acid N, ammonia N, cobalt and ytterbium.

Results and Discussion

Experiment 1

Total tract digestibilities of OM ($P<.07$), starch ($P<.06$), N ($P<.12$) and ADF ($P<.07$) decreased when 12 percent roughage was added to the diet (Table 1). The depression was greater than expected simply from addition of the less digestible material. In this experiment, adding 12 percent roughage depressed OM digestibility 1.6 percentage units more than expected, a negative associative effect. This was due largely to depressed starch digestibility. The animals fed all concentrate (100C) consumed 124 g more starch and digested 149 g more starch than the 88C heifers. Nitrogen digestion was slightly greater with the 100C diet (71.4 vs 70.0 percent). Digestibility of the diet containing 12 percent roughage (88C) may be lower than expected due to 1) faster flow of particulate matter from the rumen, 2) increased competition between microbes digesting starch and fiber and 3) higher fiber content of postruminal digesta. Higher amounts of fiber in the small intestine may speed passage rate through the small intestine. Faster flow of intestinal digesta may decrease the opportunity for digestion in the small intestine or time for fermentation in the large intestine.

Experiment 2

Fluid dilution rate of ruminal contents (Table 2) tended to be greatest for the 12 percent chopped alfalfa diet (ALF) and least for the

Table 1. Intakes and total tract digestibilities, experiment 1.

Item	Diet		Expected
	100C	88C	for 88C
Organic matter			
Intake, g	1944	1952	
Digestibility, %	81.4	75.7	77.3
Starch			
Intake, g	1097	973	
Digestibility, %	89.7	85.8	89.7
Nitrogen			
Intake, g	43	43	
Digestibility, %	71.4	70.0	68.2
Acid detergent fiber			
Intake, g	127	233	
Digestibility, %	58.3	45.5	

Table 2. Fluid and particle passage rates, experiment 2.

Item	Diet			
	ALF	HULLS	WSC	MILO
Fluid dilution rate, %/h	8.0	7.4	6.9	7.5
Fluid volume in rumen, liter	14.8	14.1	16.2	15.6
Rolled milo passage rate, %/h	4.1	2.9	2.6	2.8

12 percent whole shelled corn ration (WSC). The 100 percent concentrate diet (MILO) was expected to produce slowest dilution rates due to reduced rumination activity and saliva flow. Ruminal fluid volume and dilution rate were related negatively ($r=-.80$; $P<.001$).

The ALF ration and the diet with 12 percent cottonseed hulls (HULLS) were expected to produce the greatest rumen fluid volumes. Greater amounts of residual roughage in the rumen may have decreased volume of free fluid capable of immediate ruminal exit. More bound or imbibed liquid with these diets would increase the time needed for re-equilibration of marker concentrations between free and bound fluid. This may have caused ruminal volumes to be underestimated with the ALF and HULLS diets to a greater extent.

The ruminal passage rate of ytterbium labeled rolled milo tended to be lowest with the WSC diet and greatest with ALF. Fluid dilution rate and particulate passage rate were positively related ($r=-.59$; $P<.03$). The WSC and MILO diets were expected to have lower particulate passage rates than ALF and HULLS animals, because of reduced rumination and saliva flow and less indigestible bulk in the rumen. The lower passage rate than expected with HULLS may be due to lack of separation of cottonseed hulls from the rumen contents as the hulls become intertwined with ruminal digesta.

Ruminal OM digestion (Table 3) was higher ($P<.05$) with the HULLS than the ALF and WSC diets. Ruminal OM digestion was correlated with particulate passage rate (Table 2; $r=-.64$; $P<.02$). OM digestion was

Table 3. Digestibilities, experiment 2.

Item	Treatment			
	ALF	HULLS	WSC	MILO
Organic matter digestion, %				
Ruminal	33.7[a]	51.1[c]	38.2[ab]	45.3[bc]
Small intestinal	25.5	7.1	24.5	17.7
Hindgut	-8.3	1.2	2.1	2.6
Total	50.9	59.4	64.7	65.6
Starch digestion, %				
Ruminal	41.0	55.2	47.6	55.5
Small intestinal	25.0	18.8	27.5	18.2
Hindgut	-1.4[a]	1.2[b]	3.1[b]	5.8[b]
Total	64.7[a]	75.2[b]	78.2[b]	79.5[b]
Nitrogen digestion, %				
Ruminal	30.3[a]	53.1[b]	22.1[a]	29.5
Small intestinal	34.4[a]	5.6[b]	37.5[a]	34.4
Total	42.5	44.2	45.6	48.7
Microbial efficiency, g MN/kg organic matter fermented	31.4	26.0	27.2	31.3

[abc]Means in a row with different superscripts differ (P<.05).

similar to values reported with 81 percent milo diets (Spicer et al., 1982). Microbial growth efficiency (Table 3) did not differ between treatments. All estimates are greater than expected with high concentrate diets, probably because of low ruminal OM digestibilities. Total tract OM digestion tended to be greatest for WSC and MILO heifers. Digestion as a percent of OM entering the small intestine was 33, 39, 12 and 31 percent for ALF, WSC, HULLS and MILO diets, respectively.

Ruminal starch digestion (Table 3) was slightly lower than in a study by Hinman and Johnson (1973) with rolled milo diets containing 7 percent cottonseed hulls and 3 percent dehydrated alfalfa meal (76.5 and 60.1 percent). Starch digestion in the rumen tended to be greater for the HULLS and MILO diets and lower for the ALF diet (Table 3). Particulate passage rate (Table 3) was negatively related to ruminal starch disappearance ($r=-.55$; $P<.05$). An influence of particulate passage rate on site of digestion may be expected with diets comprised of particles with small sizes and slow rates of digestion. Small intestinal starch digestibilities tended to be lowest for HULLS and MILO (Table 3). As a percent of starch entering the intestine, disappearance was 41, 51, 38 and 45 percent for ALF, WSC, HULLS and MILO diets, respectively. Since values were lower with added roughage, particle size and flow rate of starch through the small intestine may limit digestion. Size of starch particles from milo should be similar for all diets in this trial, but particles of whole corn starch should have a much larger particle size than the milo. Slightly lower disappearance for ALF and HULLS diets may be due to an increased intestinal passage rate due to an increased flow of indigestible bulk. Fibrous material may physically or chemically interfere with starch digestion in the small intestine (Dunaif and Schneeman, 1981), or an increased fluid flow could dilute intestinal enzymes. Total tract digestion values are in general agreement with those in experiment 1. Digestion again is lower for MILO than would be expected for rolled corn grain. Total tract starch digestion was lowest ($P<.05$) with the ALF diet.

Ruminal digestion of feed N (Table 3) tended to be greatest for the HULLS diet. Spicer et al. (1983) observed 25 percent ruminal digestion

of grain protein with an 81 percent sorghum grain diet. Particulate passage rate was negatively correlated with ruminal N disappearance ($r=-.63$; $P<.02$). Disappearance as a percent of N entering the duodenum was 39, 47, .1 and 41 percent for ALF, WSC, HULLS and MILO diets, respectively. These values are much lower than values from corn based diets and protein supplements. With such diets, small intestinal N digestion usually exceeds 60 percent (Zinn and Owens, 1983). These trends support the suggestions of either detrimental effects of fiber on small intestinal digestion or low availability of protein from milo grain. No treatment differences in N digestibility in the total tract were observed. Total tract N digestibilities were lower than the 67.9 percent predicted by NRC (1965) equation. The sum of ruminal and small intestinal digestibilities for N exceed total tract N digestibility. This reflects considerable recycling of N to the rumen for synthesis of microbial protein plus cycling of N to the large intestine which is lost as microbial protein in the feces (Goetsch and Owens, 1984). However, the amount of OM disappearance in the hindgut was low. Epithelial cell sloughing or ammonia entrapped by feces with a low pH may have been large.

Performance data with animals receiving rolled milo diets with no roughage or whole shelled corn as compared to conventional milo diets needs to be collected to determine the feasibility of reducing roughage level to increase digestibility of starch and organic matter. For acidosis prevention, ionophores will be essential components of such diets. Buffer essentiality in such diets is presently not known.

Literature Cited

Dunaif and Schneeman. 1981. Am. J. Clin Nutr 34: 1034.

Galyean, M. L., et al. 1976. J. Anim. Sci. 43:1088.

Goetsch and Owens. 1984. Okla. Agr. Exp. Sta. Res. Rep. MP-116.

Hinman, D. D. and R. R. Johnson. 1973. Okla. Agr. Exp. Sta. Res. Rep. 90:73.

Nagaraja, T. G., et al. 1982. J. Anim. Sci. 54:649.

Spicer, L., et al. 1983. J. Anim. Sci. 57(Suppl. 1):470.

Zinn, R. A. and F. N. Owens. 1983. J. Anim. Sci. 56:707.